Evidence of Hydrocarbon Seepage Using Multispectral Satellite Imagery, Kurdistan, Iraq

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The petroleum system in northern Iraq has reached a maximum expulsion phase, characterized by tectonic uplift, beveled fold and thrust structures, and active surface oil seeps. While conducting photogeologic interpretation in the region, it was observed that well exposed dip slopes exhibit spectral changes along strike, especially notable along producing antiforms near Kirkuk, Irbil, and Mosul. Proposed altered outcrops include carbonate and clastic composition, as modeled from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) shortwave-infrared (SWIR) multispectral bands. The spatial pattern of alteration may not reflect diagenesis but appears closely coincident with structure, manifested along thrusted fold fronts and eroded symmetric folds. In addition, many altered exposures correspond with known oil seeps, sour (sulfurous) water locations, and bitumenous sites identified throughout the region.

Predicting and mapping rock and soil alteration from satellite imagery is an accepted practice for mineral exploration, where heat and chemical changes from intrusions alter country rocks in phases that can be spectrally characterized and associated with ore. Geochemical alteration is noted in rocks associated with hydrocarbon microseepage and changing pH, but few investigations document this approach. It is proposed that hydrocarbon migration has altered surface rocks in Kurdistan as evidenced by digital image analysis of Landsat and ASTER satellite imagery. Spectral measurements of hand samples collected within suspect terrain show strong indicators of alteration mineralogy from exposed lower Fars formation and sandstone units. While still preliminary, the mineral jarosite appears ubiquitous in hand samples tested so far suggesting acidic, sulfate-rich surface conditions not normally associated with lithology of the region. Research is on-going and will focus on further analytical testing of both altered and unaltered exposures as well as spectral characterization and mapping using multispectral, orbiting sensors. In addition, satellite imagery proved successful for enhancing oil films on the Tigris River reservoir and in identifying active sulfurous drainage. Image analysis is shown to be a key exploration tool for this geologically complex and rugged terrain.